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POTENTIAL OF INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM (IMTA)

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INTRODUCTION

IMTA is the practice that combines the cultivated of fed aquaculture species (e.g., finfish/shrimp) with organic extractive aquaculture species (e.g., shellfish/herbivorous fish) and inorganic extractive aquaculture species (e.g., seaweed) to create balanced ecological systems for conservational sustainability and economic stability (product diversification and risk reduction. This system is different from the 'Polyculture' based system (Shah et al. 2017).

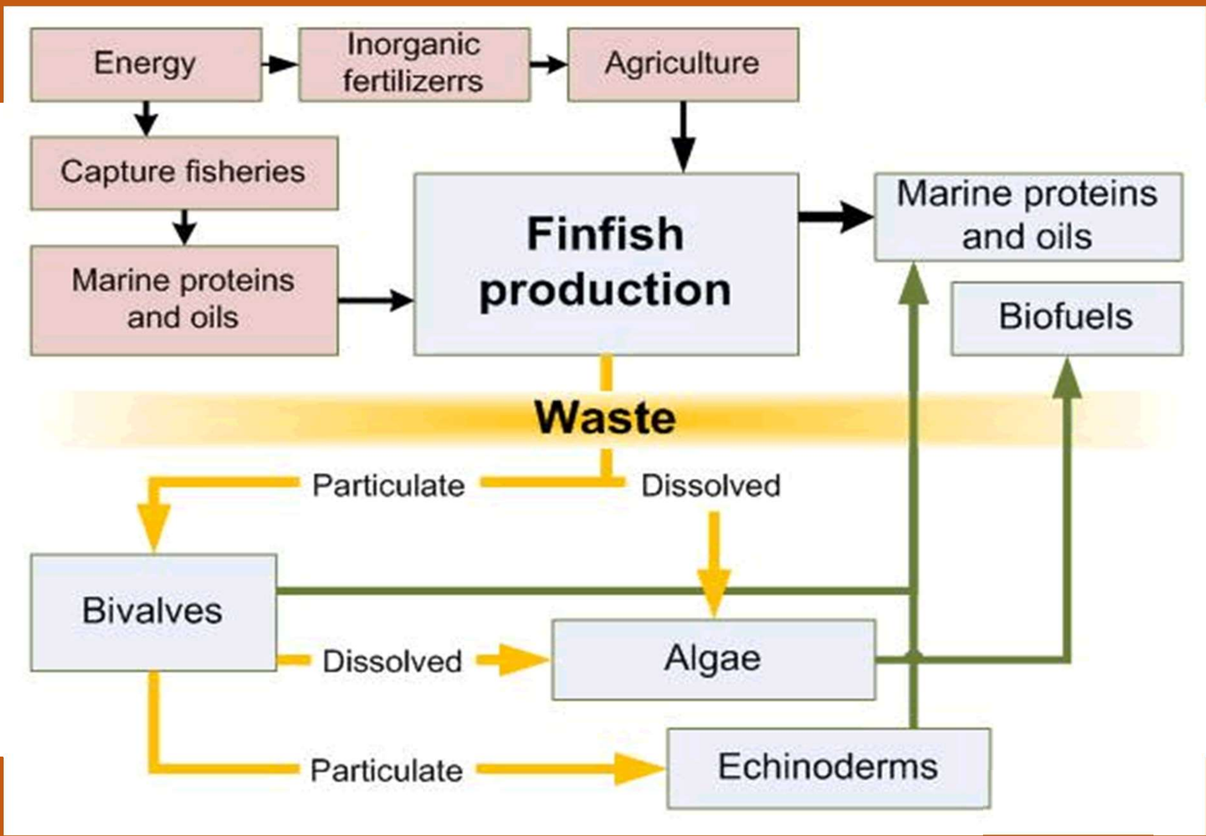
Worldwide mostly practiced the polyculture-based culture system in different coastal areas but lacked a problem they face, like properly balanced feed. IMTA is the most beneficial and sustainable system is developed globally. It is an IMTA. IMTA simple way to diffed as the farming of aquaculture species from different trophic levels and with complementary ecosystem functions, in a way that allows one species' uneaten feed and wastes, nutrients, and by-products to be recaptured and converted into fertilizer, feed, and energy for the other crops, and to take advantage of synergistic interactions between species. IMTA is based on principle nitrification and conversion through diversification (Barrington et al. 2009)

In this system, selecting appropriate species and sizing the various populations to provide essential ecosystem functions allows the biological and chemical processes involved to achieve a stable balance, mutually benefiting the organisms and improving ecosystem health. Ideally, the co-cultured species each yield valuable commercial "crops." IMTA can synergistically increase total output, even if some of the crops yield less than they would, short-term, in a monoculture. The primary function of IMTA

"Integrated" refers to intensive and synergistic cultivation, using waterborne nutrient and energy transfer. "Multitrophic" means that the various species occupy different trophic levels, i.e., different (but adjacent) links in the food chain. IMTA is a specialized form of the age-old practice of aquatic polyculture, which was the co-culture of various species, often without regard to trophic level. In this broader case, the organisms may share biological and chemical processes that are minimally complementary, potentially leading to significant ecosystem shifts/damage. Some traditional systems did culture species that occupied multiple niches within the same pond but limited intensity and management.

The more general term "Integrated Aquaculture" is used to describe monocultures' integration through water transfer. The terms "IMTA" and "integrated aquaculture" differ primarily in their precision and are sometimes interchanged. Aquaponics, fractionated aquaculture, integrated agriculture-aquaculture-systems, integrated peri-urban-aquaculture-systems, and integrated fisheries-aquaculture-systems are variations in the IMTA concept.

3. The government should be support and promoting to the farmers and commercialization of IMTA technology.
4. Recognizing the benefits of IMTA and educating stakeholders about this practice.
5. Establishing the R&D&C continuum for IMTA.



Layout of Integrated multi-trophic aquaculture System (IMTA)

THE DIFFERENT STEP SHOULD BE NEED DEVELOPMENT OF IMTA

1. To develop the economic and environmental value of IMTA systems and their co-products.
2. Species should be selecting the right, appropriate to the habitat, available technologies, and oceanographic conditions

SELECTION OF SPECIES

Species selection is the most important and useful factor in IMTA aquaculture because it is a growing semi-naturally handling system. Suitable for ecological balance and sustainability is the primary consideration in IMTA. Fed organisms, such as predatory fish and shrimp, are nourished by feed, comprising pellets or trash fish. Extractive organisms extract their nourishment from the environment. The two economically significant cultured groups that fall into this category are bivalves and seaweed. Combinations of co-cultured species will have to be carefully selected according to several conditions and criteria:

- **Complementary roles with other species in the system:** Use species that will complement each other on different trophic levels.
- **Adaptability concerning the habitat:** Native species that are well within their normal geographic range and available technology can be used. This will help prevent the risk of invasive species causing harm to the local environment and potentially harm other economic activities.
- **Culture technologies and site selection:** Particulate organic matter and dissolved inorganic nutrients should be both considered, as well as the size range of particles when selecting a farm site.
- **Ability to provide both efficient and continuous bio-mitigation:** Use species capable of growing to significant biomass. This feature is vital if the organisms act as a bio-filter that captures many of the excess nutrients and can be harvested from the water.
- **Market demand for species:** Use species that have a growing market value. Farmers must be able to sell alternative species to increase their economic input.
- **Commercialization potential:** Use species, for which regulators and policymakers will facilitate the exploration of new markets, not impose new regulatory impediments to commercialization.

IMTA SYSTEM DESIGNS:

An effective IMTA operation requires the selection, arrangement, and placement of various components or species to capture both particulate and dissolved waste materials generated by fish farms. The selected species and system design should be engineered to optimize the recapture of waste products. As larger organic particles, such as uneaten feed and feces, settle below the cage system, they are eaten by deposit feeders, like sea cucumbers and sea urchins. Simultaneously, the fine suspended particles are filtered out of the water column by filter-feeding animals like mussels, oysters, and scallops. The seaweeds are placed a little farther away from the site in the direction of water flow so they can remove some of the inorganic dissolved nutrients from the water, like nitrogen and phosphorus. IMTA species should be economically viable as aquaculture products and cultured at densities that optimize the uptake and use of waste material throughout the production cycle.

PRESENT STUDIES OF IMTA WORLDWIDE: -

In this culture, technology beneficial to ecological and sustainability globally. Nowadays, IMTA commonly culture practices worldwide. In temperate waters, Canada, Chile, China, Ireland, South Africa, the United Kingdom of Great Britain and Northern Ireland (mostly Scotland), and the United States of America are the only countries to have IMTA systems near the commercial scale. France, Portugal, and Spain have ongoing research projects related to the development of IMTA. The countries of Scandinavia, especially Norway, have done some individual groundwork towards the development of IMTA, despite possessing an extensive finfish aquaculture network (Barrington et al. 2009).

Studies have focused on integrating seaweeds with marine fish culture for the past fifteen years in Canada, Japan, Chile, New Zealand, Scotland, and the USA. The integration of mussels and oysters as bio-filters in fish farming has also been studied in several countries, including Australia, the

USA, Canada, France, Chile, and Spain. Recent IMTA research includes a focus on seaweeds, bivalves, and crustaceans. Studies conducted in an IMTA system incorporating *Gracilaria lemaneiformis* and *Chlamys farreri* in North China have shown a bivalve/seaweed biomass ratio from 1:0.33 to 1:0.80 was preferable for efficient nutrient uptake and for maintaining lower nutrient levels. Results indicate that *G. lemaneiformis* can efficiently absorb ammonium and phosphorus from scallop excretion.

In China reported the Seaweeds, *Gracilaria lemaneiformis*, grown over 5 km of culture ropes near fish net pens on rafts increased the density from 11.16 to 2025 g/m 3-month growing period. During the following 4 months to 80 km of rope, the scaling up of culture area reported an increase in culture density on ropes to 4250 g/m. An increase in the biomass of Gracilaria (in the culture area) to 340 tonnes wet weight was estimated due to its culture close to fishnet pens. Different work along similar principles have taken place elsewhere.

Studies on IMTA have been carried on the East coast of Canada, where Atlantic salmon (Salmo salar), kelp (*Saccharina latissima* and *Alaria esculenta*), and blue mussel (*Mytilus edulis*) were reared together at several IMTA sites in the Bay of Fundy. The study has shown that the growth rates of kelp and mussels cultured in proximity to fish farms have been 46 and 50% higher, respectively, than at control sites. Several other studies have also reflected on the faster growth of mussels and oysters grown adjacent to fish cages. This reflects an increase in nutrients and food available from the finfish cages. Taste tests of mussels grown in conventional aquaculture and mussels grown at these IMTA sites showed no discernible difference; meat yield in the IMTA mussels was, however, higher. Findings of the economic models have also shown that increased overall net productivity of a given IMTA site can increase the farm's profitability compared with monoculture.

Studies from land-based systems indicated that seaweeds could remove between 35% and 100% of the fed species' dissolved nitrogen. The capacity of seaweeds in open-water cultures to remove nutrients from the water column can be estimated based upon the fraction of available nutrients bound by the seaweeds at any given point in time. Experimental data and mass balance calculations indicated that a large area of seaweed cultivation, up to one ha for each ton of fish standing stock, would be required for the full removal of the excess nitrogen associated with a commercial fish farm.

The open-sea IMTA in India is very recent; however, various investigations have been carried out on the various mariculture species' beneficial polyculture. The collaborative culture of compatible species of prawns and fishes is of considerable importance in augmenting yield from the field and effective utilization of the pond system's available ecological niches. Finfish culture, *Etroplus suratensis,* in cages erected within the bivalve farms (racks) resulted in high survival rates and the finfish's growth in the cages. Co-cultivation of *Gracilaria sp*. at different stocking densities with Feneropenaeus indices showed nutrient removal from shrimp culture waste by the seaweed. The ratio of 3:1 was found suitable for the co-cultivation. The seaweed (600 g) reduced 25% of ammonia, 22% nitrate, and 14% phosphate from the shrimp (200 g) waste. Polyculture of shrimp with mollusks helps break down organic matter efficiently. It serves as an important food source for a range of organisms and either directly or indirectly provides shelter or creates space for the associated organism, thus increasing the ecosystem's species diversity. Studies have shown that an individual mussel can filter between 2-5 l/h and a mussel rope more than 90000 l/day. The culture of mussels could thus be used in the effective removal of phytoplankton and residues and reduce the eutrophication caused by aquaculture.

Along the east coast of India, the introduction of IMTA in open sea cage farming yielded 50% higher production of seaweed, *Kappaphycus alvarezii*, when integrated with finfish farming of *Rachycentron canadum*. Open-sea mariculture of finfishes, when integrated with raft culture of green mussels, *P. Viridis* resulted in a slight but not significant reduction in nutrients along with Karnataka. The beneficial effect of combining bivalves such as mussels, oysters, and clams as bio-filters in utilizing such nutrient-rich aquaculture effluents has been documented in estuaries. In a tropical integrated aquaculture system, the farming of bivalves (*Crassostrea madrasensis*) along with finfish (*Etroplus suratensis*) resulted in controlling eutrophication effectively (Viji et al., 2013, 2015). The filter-feeding oysters improved the clarity of the water in the farming area, thereby reducing eutrophication. The optimal co-cultivation proportion of fish to oysters reported was 1:0.5 in this farming system.

BENEFITS:

- Mitigation of effluents through bio-filters is suited to the ecological niche of the aquaculture site. This can solve a number of the environmental challenges posed by monoculture aquaculture.
- The increased overall economic value of an operation from the commercial by-products that are cultivated and sold. The complexity of any bio-filtration comes at a high financial cost. To make environmentally friendly aquaculture competitive, it is necessary to raise its revenues.
- Improving economic growth through employment (both direct and indirect) and product processing and distribution.
- Certain seaweeds can prevent disease prevention or reduce disease among farmed fish due to their antibacterial activity against pathogenic fish bacteria.
- Potential for differentiation of the IMTA products through eco-labeling or organic certification programs.

CHALLENGES IN IMTA

- **Higher investment:** Integrated farming in the open sea requires a higher level of technological and engineering sophistication and up-front investment.
- **Difficulty in coordination**: If practiced utilizing different operators (e.g., independent fish farmers and mussel farmers) working in concert, it would require close collaboration and coordination of management and production activities.
- **Increase the farming area requirement:** While aquaculture can release pressure on fish resources and IMTA has specific potential benefits for the enterprises and the environment, and fish farming competes with other users for the scarce coastal and marine habitats. Stakeholder conflicts are common and range from concerns about pollution and impacts on wild fish populations to site allocation and local priorities. The challenges for expanding IMTA practice are therefore significant. However, it can offer a mitigation opportunity to those areas where mariculture has a low public image and competes for space with other activities.

- **Difficulty in implementation without open water leasing policies:** Few countries have national aquaculture plans or well-developed integrated management of coastal zones. This means that decisions on site selection, licensing, and regulation are often and highly subject to political pressures and local priorities. Moreover, as congestion in the coastal zone increases, many mariculture sites are threatened by urban and industrial pollution and accidental damage.

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